(ii) $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + \cdots$

(iii) $^{22}_{11}Na \rightarrow ^{22}_{10}Ne + \cdots + \cdots$ (5)

(b) What do you mean by activity of a sample? Give its units and write their relation. Determine the activity of 1.0 g of ^{90}Sr whose half-life against β – decay is 25 years. (3,3,4)

Given : mass of $^{12}_{6}C$ = 12.000000 u, mass of $^{4}_{2}He$ = 4.002603 u,
mass of $^{59}_{27}Co$ = 58.933198 u,
mass of $^{1}_{1}H$ = 1.007825 u, mass of $^{2}_{1}H$ = 2.014102 u,
m_p = 1.007276 u, m_n = 1.008665 u, m_e = 0.000548 u,
1 u = 1.66054 x 10^{-27} kg, h = 6.62 × 10^{-34}Js,

ϵ_0=8.85 × 10^{-12} F/m

8 Dec

[This question paper contains 8 printed pages.]

Your Roll No.

Sr. No. of Question Paper : 1654

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. Prog. – CBCS_DSE**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** questions. (3×5)

(a) A source of light of wavelength 300 nm with an intensity of 1.0 W/m^2 is incident normally on a potassium surface of area 1.0 cm^2. Determine the number of photoelectrons emitted per second provided 0.4 % of the incident photons produces photoelectrons.

(b) Enlist two shortcomings of Rutherford's atomic model.

(c) An electron is confined to a box of length 10^{-8} m. Calculate the minimum uncertainty in its velocity.

(d) What are stationary states?

(e) A particle of mass m confined to move in a potential $V(x) = 0$ for $0 \leq x \leq a$ and $V(x) = \infty$ otherwise. The wave function of the particle at time $t = 0$ is

$$\psi(x,0) = A\left(2\sin\frac{\pi x}{a} + \sin\frac{3\pi x}{a}\right)$$

Determine A.

(b) Determine the normalized wavefunction of a particle trapped inside a one dimensional infinitely rigid box of 0.1 nm wide and hence deduce the expectation value $\langle x \rangle$ of the position of a particle. (8)

7. (a) Write the semi-empirical binding-energy formula for a nucleus of mass number A, containing Z-protons and N-neutrons and explain each term appeared in the expression. (5)

(b) (i) Find the energy needed to remove a neutron from the nucleus of the Cobalt isotope $^{59}_{27}Co$. (4)

(ii) Find the energy required to remove a proton from this nucleus. Why these energies are different? (4,2)

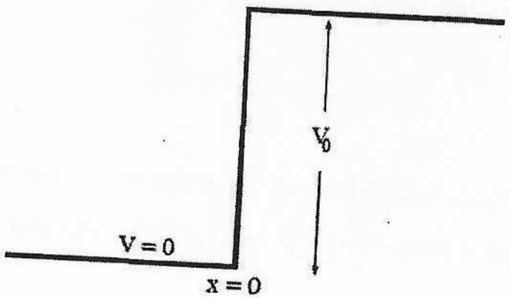
8. (a) Complete the following reactions

(i) $^{14}_{6}C \rightarrow ^{14}_{7}N + \cdots + \cdots$

$$\frac{\partial \rho}{\partial t} + \overline{\nabla}.\overline{J} = 0$$

6. (a) Consider a one-dimensional rectangular potential of height V_0 defined by

$$V(x) = 0 \quad \text{for } x < 0$$
$$= V_0 \quad \text{for } x > 0$$



A stream particles of mass m having energy $E < V_0$, moves from left to right. Obtain the expressions for the reflection and transmission coefficients of the particle. (7)

(f) Show that nuclear density is a constant, independent of the number of nucleons in the nucleus.

(g) A certain radioactive material has a half-life of 50 days. What is the decay constant and mean life of this element?

2. (a) When an X-ray photon is scattered by an electron (assumed to be initially at rest in the laboratory coordinate system), show that the changed in the wavelength of the scattered photon is given by

$$\lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\varphi)$$

where m_0 is the rest mass of the electron and φ is the angle through which the photon is scattered. (10)

(b) A moving electron has a de-Broglie wavelength equal to its Compton wavelength. Find its speed. (5)

3. (a) Explain the consistency of Bohr's quantization rule with de-Broglie's hypothesis. (5)

(b) The ionization energy of a hydrogen like Bohr atom is 8.0 rydberg.

(i) Determine the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state.

(ii) Calculate the radius of the first orbit for this atom. (5,5)

4. (a) State Heisenberg's uncertainty principle for position and momentum measurement. Explain how the gamma ray thought experiment validates this principle. (5)

(b) The speed of an electron is measured to be 5.3×10^3 ms^{-1} to an accuracy of 0.005%. Find the minimum uncertainty in determining the position of this electron. (5)

(c) Using the Heisenberg uncertainty relation in the form pr = $\hbar$, derive an expression for the minimum radius r_1 and energy E_1 of a hydrogen atom. (5)

5. (a) The wave function for a particle moving along the positive x-direction is given by

$$\psi(x,t) = Ae^{i(kx-\omega t)}$$

Using this obtain an expression for the momentum and kinetic energy operator in one dimension. (5)

(b) Discuss the probability interpretation of a wave function. Show that the probability density p and probability current density $\overline{J}$ satisfies the continuity equation (10)